COLD SPRING CREEK

Cold Spring Creek – Debris Basin Design

Rev. A
January 9, 2021

Project No.: 1572-007

Prepared by BGC Engineering Inc. for:
Regional District of East Kootenay

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TABLE OF REVISIONS

ISSUE	DATE	REMARKS
Revision A	January 9, 2020	Preliminary design issued for funding application.

LIMITATIONS

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EXECUTIVE SUMMARY

The Regional District of East Kootenay (RDEK) is proposing to mitigate against debris floods and debris flows on Cold Spring Creek, which pose a risk to the community of Fairmont Hot Springs. This report provides the basis and preliminary design for protecting the existing development from debris floods and debris flows.

A preliminary life loss risk assessment was completed by BGC. It demonstrated that life-loss risk to individuals from debris flows ranged from 1.5 times to 32 times the risk commonly tolerated for existing development in BC (EGBC, 2021). It also showed that group risk is over one order of magnitude higher than commonly deemed tolerable. **This demonstrates a very high-risk profile for the community of Fairmont Hot Springs which emphasizes the need for and urgency of debris flow risk reduction**.

The objective of the proposed mitigation is to reduce debris flow and debris flood risk to levels deemed tolerable by the RDEK. The preliminary mitigation design is accompanied by a Class D cost opinion, intended to support a funding application. Detailed design with tender-appropriate costing will be developed at a later date.

The design event balances maximum life loss risk reduction, technical feasibility and total cost constraints. The design event for this structure is slightly larger than the 100 to 300-year return period debris flow. Debris flows with discharges and volumes in excess of the design event will be reduced in intensity before reaching the development on Cold Spring Creek fan.

The mitigation design at Cold Spring Creek has three key components:

1. Deflection Structure and Inlet Ramp – A deflection structure which deflects debris floods into the debris basin but allows normal clearwater flows to pass towards the existing Fairmont Hot Springs Resort Pond.
2. Barrier and Debris Basin – An earth fill berm armoured against erosion and a debris basin that provides approximately 68,000 m^3 storage capacity. A steel rack and concrete outlet structure will filter (i.e. stop) debris and allow water to pass. An overflow weir located above the rack will spill events that are larger than the design event. A concrete stilling basin will receive flows on downstream side of the outlet.
3. Outlet Channel – The outlet channel immediately downstream of the stilling basin will be armoured to prevent channel erosion or undermining of the stilling basin.

The estimated Class “D” cost opinion is for $9.72 Million (in 2021 Canadian Dollars), which includes a 50% contingency.

The proposed debris basin and auxiliary structures will be refined during the detailed design stage which, upon successful ARDM funding will occur in the spring of 2021. None of the information or drawings provided in this report are for tendering or construction. The RDEK and their consulting team reserve the right to change, refine or amend aspects of the design as needed.

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1. INTRODUCTION

Cold Spring Creek has a history of damaging debris floods with 4 events in the last 10 years alone that exceeded the current channel and culvert capacities. In 2015, a hazard and risk assessment was conducted by Clarke Geoscience and EBA Tetra Tech (March 1, 2015). In 2020, BGC Engineering Inc. (BGC) updated the previous assessment with a variety of quantitative methods and provided individual hazard scenarios and composite hazard maps (BGC, September 25, 2020).

To support eventual detailed design of mitigation works, BGC and McElhanney were retained by the Regional District of East Kootenay (RDEK) to complete a mitigation options assessment and a quantitative risk assessment for Cold Spring Creek, both studies are ongoing and informed the present design.

In the spring of 2021, a near real-time debris flow warning system will be designed for Cold Spring and Fairmont creeks. This system will likely become operable as a test-version sometime in 2021 and released for public use in 2022. It is meant as an auxiliary risk reduction measures for both Cold Spring and Hot Springs Creek and could also warn personnel during construction of the proposed debris basin.

The RDEK retained BGC to identify a preferred mitigation option for the purpose of supporting the Adaptation, Resilience and Disaster Mitigation (ARDM) grant funded by the federal government and administered by Emergency Management BC (EMBC). The ultimate goal of the proposed mitigation works is to reduce risk caused by debris floods and debris flows to developments and infrastructure on Cold Spring Creek fan. This report is being carried out under BGC's standard terms and conditions, signed between BGC and McElhanney on September 18, 2020.

1.1. Scope

BGC and McElhanney were retained by the RDEK in December of 2020 to complete the following tasks. RDEK (conference call December 29, 2020) directed BGC to:

- Provide an option analysis for mitigation works. BGC (December 16, 2020) evaluated conceptual mitigation options and recommended a debris filter design (i.e., retain solids while allowing water to pass).
- Provide a quantitative risk assessment for mitigation works (to be documented in separate report).
- Summarize the preferred mitigation option design in this document.

2. BACKGROUND

The regional and local watershed geology, geomorphology, and hydrology are described in BGC's previous hazard assessments (BGC, September 25, 2020).

Debris floods and debris flows were numerically modelled, using FLO-2D (FLO-2D Software, 2020), for the return periods summarized in (Table 2-1).

Table 2-1. Summary of peak discharge and debris volume estimates (BGC, September 25, 2020).

Return Period (years)	Process	Debris Volume Best Estimate (m^3)	Peak Discharge (m^3/s)
3 to 10	Debris Flood	4,400	2.4
10 to 30	Debris Flood	4,800	3.8
30 to 100	Debris Flood	5,200	5.2
100 to 300	Debris Flow	64,000	210
300 to 1000	Debris Flow	76,000	260
1000 to 3000	Debris Flow	96,000	320

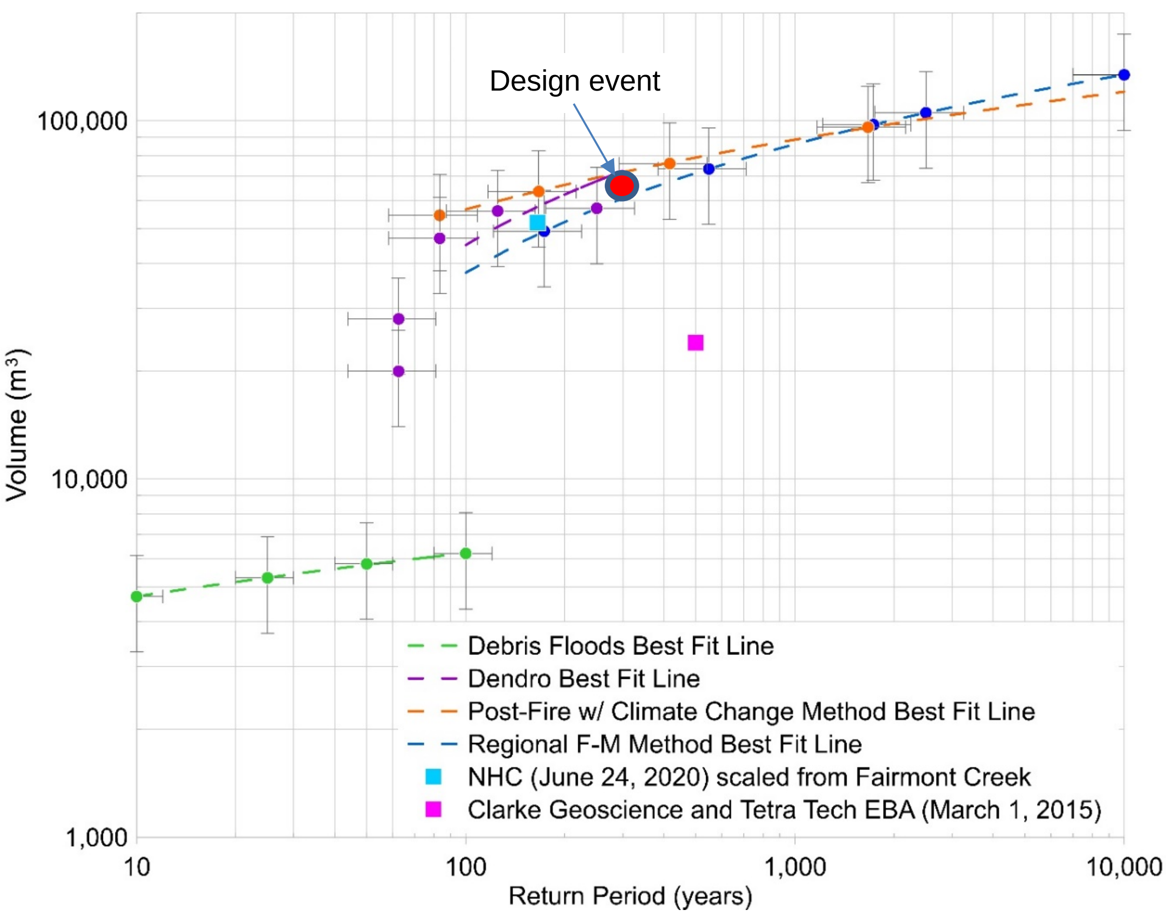

Figure 2-1. The frequency-volume methods considered reasonable for Cold Spring Creek (BGC, September 25, 2020).

3. PRELIMINARY RISK ASSESSMENT

BGC conducted a preliminary quantitative life loss risk assessment to inform the selection of the design event.

In conducting quantitative risk assessments (QRAs) for loss of life, one typically assesses individual life loss (also known as the probability of death to individuals or PDI) and group risk (also known as societal risk).

Individual risk typically focuses on the person judged to be most at risk, corresponding to a person spending the greatest proportion of time in the landslide zone, such as a young child, stay-at-home person, or an elderly person. Individual risk is calculated as follows:

$$PDI_j = \sum_{i=1}^{n} P(H)_i P(S|H)_{i,j} P(T|S)_{i,j} V_{i,j} \qquad \text{Eq. 1}$$

where:

- PDI_j is the PDI at a given parcel (j)
- $P(H)_i$ is the annual probability of a geohazard scenario[1] (i)
- $P(S|H)_{i,j}$ is the spatial probability of impact of geohazard scenario (i) at a given parcel (j)
- $P(T|S)_{i,j}$ is the temporal probability of a person occupying a building at parcel (j)
- $V_{i,j}$ is the probability of fatality (vulnerability) given impact by the estimated hazard intensity[2]
- n the number of geohazard scenarios

Group risk evaluates the number of people that could be killed by a flow landslide related hazard, considering all people located within the Consultation Zone. Group risk is derived from f-N pairs where the annual probability of a given geohazard scenario, f_i, corresponds with an estimated number of fatalities, N_i defined as follows:

$$f_i = P(H)_i$$

$$N_i = \sum_{j=1}^{n} P(S|H)_{i,j} P(T|S)_{i,j} V_{i,j} E_j \qquad \text{Eq. 2}$$

where:

- $P(H)_i$, $P(S|H)_{i,j}$, $P(T|S)_{i,j}$, and $V_{i,j}$ are the same as defined in Equation 2 with *n* being the total number of individual parcels; and
- E_j is the number of people exposed to the hazard in parcel (j).

BGC simplified the risk assessment as follows to determine individual risk and group risk:

[1] Note that the probability of a geohazard scenario is the product of event probability, avulsion probability, (where applicable) and flow mobility probability.
[2] Intensity refers to the destructive potential of a landslide at the parcel level

- Delineation of zones of relatively equal hazard for each of the three debris flow hazard scenarios (return periods 100 to 300, 300 to 1000 and > 1000 years).
- Estimation of hazard probability P(H) had been done by BGC (2020) for Cold Spring Creek.
- Estimation of temporal probability P(T|S) as 0.5 for all properties (group risk) and 0.9 for individual risk. This implies an assumption that typical residents are present half the day (12 hours), whereas for the individual risk, the person most at risk (old person or infant who rarely leaves the house) is present 90% (~22 hours) of the day. BGC learned from the RDEK that only 57% of the homes on Cold Spring Creek fan are permanent residences and 43% are part time. To reflect the current reality, BGC estimated group risk for part-time residency and full-time residency.
- Estimation of spatial probability P(S|H) of impact was based on the numerical modeling results. Spatial probability estimates ranged from 0.5 to 0.9 and reflect the percentage of homes that are impacted by the flow within each hazard zone.
- Estimation of vulnerability (V) which reflects the chance of a person dying in a building that is impacted by a debris flow. BGC used calibrated data from previous projects and based on analysis by Jakob et al. (2011) to estimate vulnerabilities of people inside buildings. Vulnerability estimates range from 2% likelihood for “low” hazard zones to 60% likelihood for “very high” hazard zones.
- Estimation of the elements at risk (E) was accomplished only for group risk by counting the buildings within each hazard zone for each of the three return period classes considered. Each building was assumed to contain 2.2 people.

The results from the analysis demonstrated that:

- Individual risks for homes on Cold Spring Creek fan are mostly unacceptable apart from properties affected only by low intensity debris flows for the 100 to 300, 300 to 1000 and greater than 1000 return periods. Approximately 68 (part-time occupancy included) to 74 (full-time occupancy) properties, occupied by approximately 110 to 160 people, are subject to unacceptable individual risk.
- PDI risk values ranged from 1.5 times to 32 times the risk commonly tolerated for existing development in BC (Annual risk of death greater than 1 in 10,000; EGBC, 2021). **This demonstrates a very high-risk profile of the community of Fairmont Hot Springs which emphasizes the need for and urgency of debris flow risk reduction**.
- Group risk was estimated as being over an order of magnitude above what is generally considered tolerable as indicated by the dashed reference line on Figure 5-1. This is the case for the assumption of full-time and part-time occupancy.
- The perpendicular distance of the individual group risk estimates to the dashed reference line in Figure 5-1 (see green double-sided arrows) is a measure of risk intensity. It shows that the 100 to 300-year return period debris flow results in the highest risk (highest combination consequence and likelihood of occurring), even though the > 1000-year return period debris flow results in the highest potential number of fatalities (14).

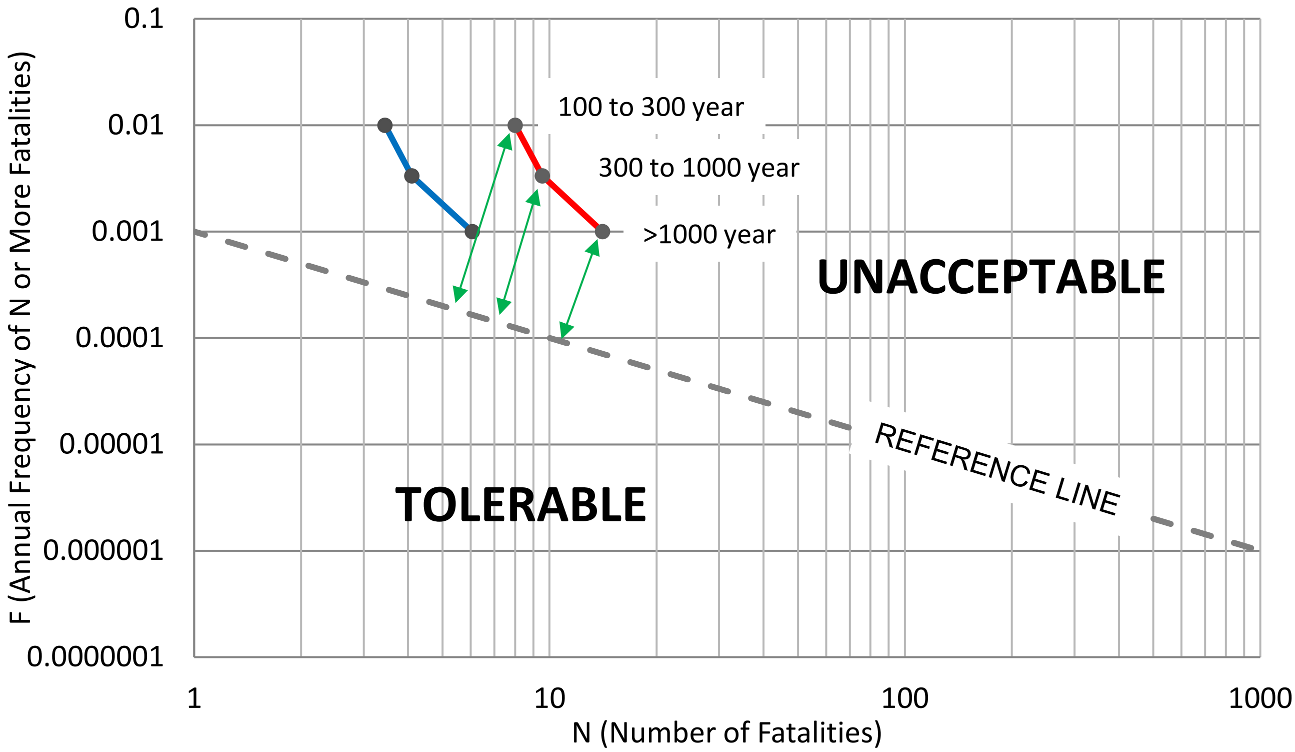

Figure 3-1. Preliminary group risk analysis for the three risk scenarios (100-300, 300-1000 and 1000-3000-year return period debris flows). Part time occupancy (present condition) is indicated by the blue line while full-time occupancy is indicated by a red line. The green arrows indicate the absolute risk as measured by distance from the grey reference line.

The proposed mitigation aims to maximize individual and group risk reduction, ideally into the tolerable zone or below the reference line in Figure 3-1.

4. MITIGATION OPTIONS ANALYSIS COLD SPRING CREEK

4.1. Conceptual Solution Pre-screening

BGC (December 16, 2020) pre-screened conceptual mitigation solutions and concluded that:

- Debris source stabilization in the watershed is not technically feasible and is cost inefficient.
- Debris deflection solutions on the fan would transfer risk, require buy-out of several properties, extensive stakeholder engagement and lead to project delays and excessive costs. BGC advised against including deflection options from further analysis.
- Debris filter solutions would capture, or at least reduce, the volume and intensity of debris flows before they reach development on the fan. Options could be sized based on available budget, designed to minimize maintenance, and debris filter structures at different locations could be combined to achieve mitigation against larger events. BGC concluded that debris filtration provided the best mitigation strategy.

4.2. Conceptual Options Analysis

Figure 4-1 illustrates the approximate location of various mitigation options considered by BGC.

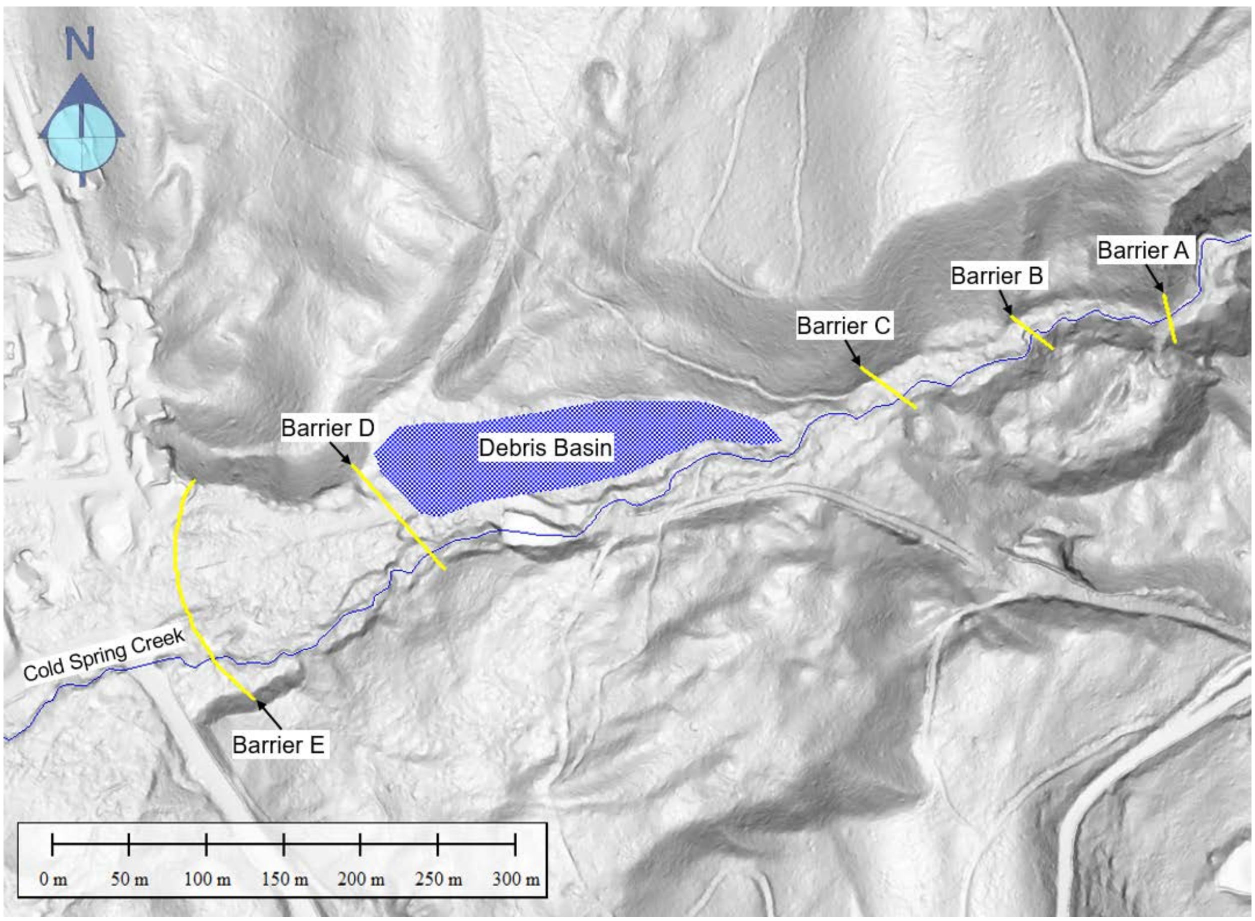

Figure 4-1. Various locations of debris flow mitigation options considered at Cold Spring Creek. Extents and shapes are schematic only.

Table 4-1 summarizes the physical mitigation measures considered by BGC for Cold Spring Creek, including a description of the method, and qualitative scoring of life safety, technical feasibility, cost effectiveness to arrive at a relative ranking of preferred measures. Score definitions are provided in the footnote of Table 4-1. Note that individual measures (e.g., Option 2 and 3) could be combined.

RDEK, BGC and McElhanney conclude that Option 3 at Site D is the most favourable option. This option was advanced to preliminary design level to support an ARDM grant application, as described in the following sections.

Table 4-1. Conceptual mitigation options analysis Cold Spring Creek

Option	Location	Method	Description	Life Safety	Technical Feasibility	Cost Effectiveness	Rank	Recommendations
1	Do Nothing	Do Nothing	Do Nothing.	(--)	(++)	(++)	6	Not Recommended
2	Site A, B, C	Debris Nets or equivalent structures	Retain debris through flexible net for a storage height of approximately 5 m and a total storage volume of up to 20,000 m^3.	(+) Tolerable risk not achieved due to insufficient storage capacity	(+) Technically feasible but would require in-channel work. Difficult to permit. May require access road disturbing current channel or over presumably dormant landslide. Cannot be upgraded individually.	(+) Moderate cost for a mitigation measure, substantial costs associated with access road construction and off-site debris storage	2	Recommended, but individual structures do not achieve risk reduction target
3	Site D	Debris Basin	Retain debris for both debris floods and debris flows, could be constructed to allow storage of 100 to 300-year return period debris flow (64,000 m^3).	(++) Tolerable risk achievable	(++). Technically feasible. All on land owned by stakeholder (Fairmont Hot Springs Resort). Various design elements can be constructed simultaneous. Can be upgraded to account for climate change effects or capture larger volume (higher return period event).	(++) Low maintenance costs for frequent debris floods due to large storage capacity. Robust design elements with simple maintenance requirements.	1	Recommended, preferred option (probably cheaper than Option 4 and farther from dwellings)
4	Site E	Berm and Outlet Structure	Construct cut-off berm or block inlet of the side channel with riprap armour to avoid new channel formation along Highway 93/95	(++) Tolerable risk achievable	(++) Technically feasible and similar to Option 3, however would require larger earthworks. major earthworks and very large berm but costly to build berms with launch apron to avoid undercutting on the outside of a channel bend. Also, this option is likely difficult to permit from an environmental point of view.	(+) Generally similar to Option 3 but more expensive.	3	Conditionally recommended
5	Fan	Deflection Berm	Deflect debris flows from high density development to low density development. Would require property acquisitions. Would jeopardize golf course operations and major clean-up costs, would require major infrastructure re-design	(+) Tolerable risk only achievable if stakeholders agree to property acquisitions to avoid risk transfer	(+) Technically feasible but very costly due to the length (~ 600 m) to be protected. May not attain stakeholder agreement and approval.	(-) Costly due to property acquisitions and major infrastructure reconstruction, declines in revenue from golf course operations, cleanup costs after big events	4	Not recommended
6	Watershed	Watershed Stabilization	Identify and stabilize debris sources. Would require intricate network of very expensive access roads. Would be very intrusive and near impossible to stop all debris sources. Extremely maintenance intensive.	(-) Unlikely to achieve risk tolerability targets	(--) Not feasible due to the shear number of debris sources, complicated and expensive access roads, construction in extremely difficult terrain. Highly uncertain performance.	(--) Very costly and will require substantial maintenance.	5	Not recommended

Qualitative Scoring Notes:

Life Safety & Technical Feasibility	Costs Effectiveness
+ + = highly beneficial	+ + = mitigation substantially cheaper compared to value of elements at risk
+ = beneficial	+ = mitigation cheaper compared to value of elements at risk
0 = neutral	0 = mitigation benefit is about the same as cost
- = undesirable	- = costs exceed value of elements at risk
- - = highly undesirable	- - = costs substantially exceed value of elements at risk

5. DESIGN CONSIDERATIONS

This section describes the basis, constraints, and assumptions considered as part of the preliminary design development of a debris filtration structure.

5.1. Relevant Design Guidelines and Regulations

The proposed preliminary design was prepared to support the ARDM grant application. The following guidelines should be considered for detailed design:

- Engineers and Geoscientists of BC (EGBC) professional practice guidelines for
  - Legislated Flood Assessments in a Changing Climate (2018)
  - Landslide Assessment Guidelines in a Changing Climate (2021, to-be-published).
- The BC Dike Design and Construction Guide (BC Ministry of Water, Land & Air Protection, July, 2003) will be used where applicable, though we note that berms designed to withstand debris flow impact will need to be designed to a higher standard than that stipulated in the BC Dike Design and Construction Guide.
- This also applies to the Riprap Design and Construction Guide (BC Ministry of Environment, Lands and Parks, March 2000) as unprotected riprap can be entrained by debris floods and debris flows. Riprap may be replaced with grouted stone pitching or other techniques such as netting to assure structural integrity where appropriate.
- The Seismic Design Guidelines for Dikes (BC Ministry of Forests, Lands and Natural Resource Operations Flood Safety Section, June 2014) will be consulted where applicable. This relates to the berm of the proposed debris basin.

Relevant regulations are discussed in Section 6.3.

5.2. Protection Concept

The mitigation concept intends to reduce the likelihood and magnitude of debris floods and debris flows affecting the existing development and potential future proposed developments. This will be achieved by retaining debris upstream of developments (i.e., filtering debris) while allowing water to continue to flow within the creek. In case of a debris flood or debris flow, the debris basin would fill, and water would be allowed to escape through a concrete outlet structure. If the debris flow volume exceeds the basin capacity, the excess debris flow volume will be passed over the concrete outlet and allowed to escape downstream.

5.3. Design Objectives

The design objectives are:

1. Reduce the risk posed by Cold Spring Creek debris floods and debris flows to the existing residential and commercial development on Cold Spring Creek fan including the MoTI road system.
2. Allow normal streamflow to pass the barrier and feed the existing Fairmont Hot Springs Resort (FHSR) Reservoir.
3. Avoid risk transfer to existing development.

5.4. Hazard Characterization

Debris floods mobilize most grains during a high discharge flood, cause extensive bank erosion, and convey large volumes of sediment and large woody debris (Church & Jakob, 2020). Debris floods at Cold Spring Creek are believed to occur with return periods of 3 to 100 years.

Debris flows are very rapid channelized flows of saturated debris in a steep channel that often cause extensive impact and sedimentation damage on fans (Hungr, Leroueil & Picarelli, 2014). According to BGC (2020), debris flows are likely to occur at return periods exceeding 100 years. There have not been any recorded debris flows for the past 50 or so years on Cold Spring Creek. The adjacent Hot Springs Creek experienced a debris flow of 65,000 m^3 volume in 2012.

5.5. Preliminary Life Loss Risk Assessment

Elements at risk in the vicinity of Cold Spring Creek include:

- The existing residential development on Cold Spring Creek fan
- The commercial developments east of Highway 93/95 including restaurants, grocery store and gas station
- The Church of Jesus Christ Latter Day Saints
- Highway 93/95
- Golf Courses and various tourist facilities.

A preliminary baseline risk assessment was completed for Cold Spring Creek. The risk assessment demonstrated that:

- Group life loss risk is unacceptable (Figure 3-1).
- Individual life loss risk tolerance (annual life loss risk greater than 1 in 10,000) is exceeded at between 68 and 72 properties on Cold Spring Creek fan with an assumed population of approximately 110 people.
- The very high group and individual risk levels provide a very strong justification for investments in debris flow mitigation.

The results of this risk assessment informed the design of steep creek mitigation measures, as described in the following sections.

5.6. Design Event Definition and Characterization

The mitigation design event informs the sizing and layout of the mitigation system. The design event is defined by three criteria:

1. The return period of the event that yields maximum life loss risk reduction.
2. That mitigation can be constructed with all contingencies for the maximum possible amount of the Adaptation, Resilience and Disaster Mitigation (ARDM) grant ($10 million) should the District be successful in their funding application.
3. That the mitigation is technical feasible and can be permitted.

The proposed mitigation strategy will capture the entire volume of the 100 to 300-year return period debris flow and reduce flow velocities and flow depth of the debris volumes of debris flows of greater than 300-year return period. The exact risk reduction achieved will be established during the detailed design phase.

Table 5-1 summarizes the preliminary design discharges and design storage capacity for sediment filtration.

Table 5-1. Design debris flow discharge and magnitude for Cold Spring Creek at the fan apex (from frequency-magnitude relationship in BGC, September 25, 2020, Table 6-8).

Return Period (years)	Process	Design Discharge (m^3/s)	Design Sediment Storage Volume (m^3)
100 to 300	Debris Flow	210	64,000

5.7. Level of Design Detail

The proposed design is at a preliminary level developed to support a funding application. Permitting applications will likely require additional details. The design is a rough layout to estimate preliminary costs of key design elements. Formal hydraulic, geotechnical or structural dimensioning was not undertaken for this Revision A of the preliminary design. This design is not intended for tender or construction. Specific details of the design, including final dimensions and layout as well as improved estimates are to be developed.

5.8. Land Ownership, Access and Environmentally Sensitive Areas

The preliminary designs assume that all land is available for construction and access to mitigation structures. The following infrastructure exists in the project area:

- Existing Fairmont Hot Spring Resort (FHSR) Dam and Reservoir
- Existing Access Road
- Existing Watermains
- Water licence Statutory Right of Way (SRW).

BGC understands the RDEK is in active conversation with stakeholders to formalize land use agreements, where required.

Environmentally sensitive areas near the project include Wetland and Riparian Ecosystems as well as Habitat for Species at Risk (Figure 5-1).

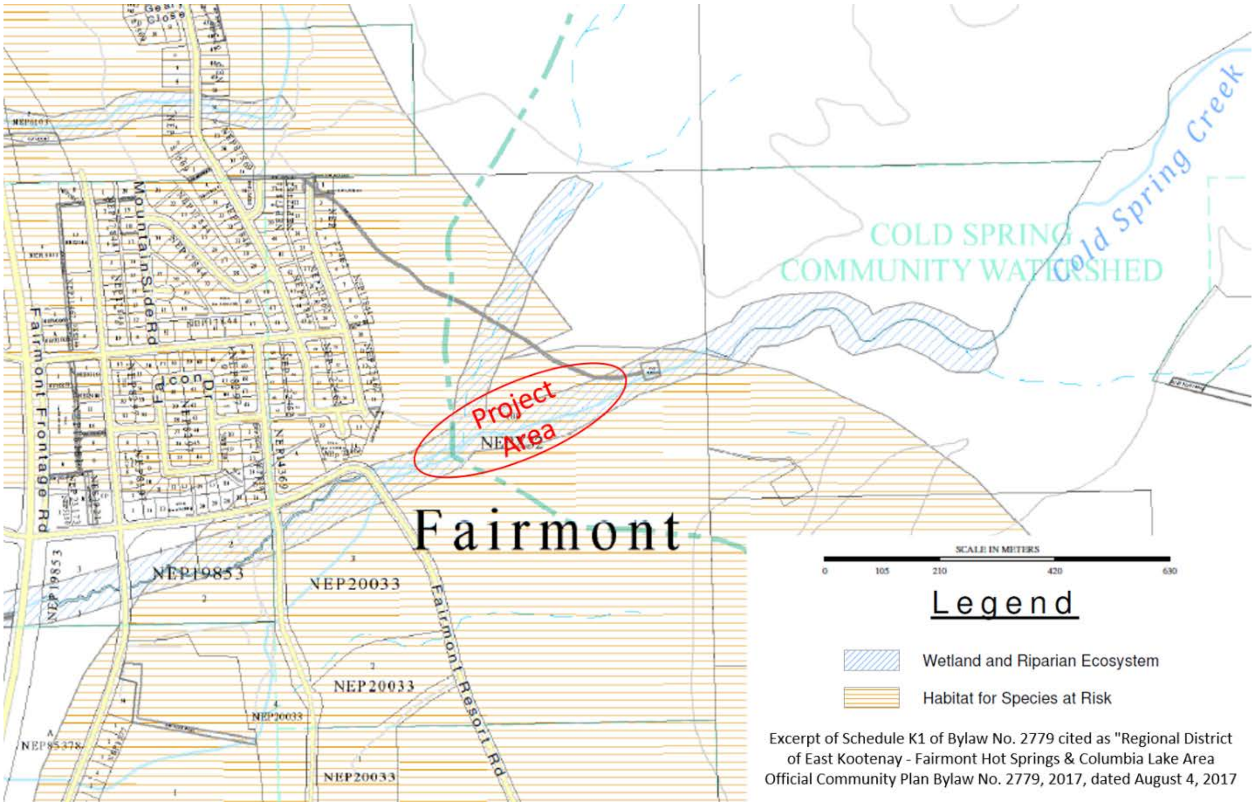

Figure 5-1. Environmentally sensitive areas near the approximate project area indicated with red oval (adapted from RDEK (2017)).

5.9. Reference Topography

Position coordinates, areas, alignments, and volumes are estimated based on the currently available lidar topography flown in 2018.

5.10. Geotechnical Parameters

Geotechnical design parameters are assumed based on terrain interpretation from lidar-derived topography, aerial photographs, and test pits in this region completed as part of the 2020 BGC hazard assessment. Detailed subsurface conditions in the footprint of the proposed basin and berms have not been investigated to date.

BGC has conducted a test pitting program at Cold Spring Creek in 2020. As this test pitting is near the study area and in a similar depositional setting, BGC has assumed that the near-surface soils are similar to Test Pit 05 in BGC (September 25, 2020) and soils exposed in natural exposures. The preliminary mitigation design assumes that soils are granular, including sand, gravel, cobbles, with some boulders (including boulders greater than 1.5 m diameter), and that the water table may be encountered during the basin excavation. Bedrock is assumed to be deep (> 10 m) and thus has no bearing on the proposed designs but will require confirmation through sub-surface investigations.

Further site investigations will be required to complete final designs.

5.11. Maintenance and Post-Event Restoration

Although maintenance requirements have not been specified at this stage, all mitigation requires periodic inspection, maintenance, and restoration, particularly following debris floods and debris flows. Restoration of the mitigation structures following debris floods or debris flows will include disposal of large woody debris and removal of sediment retained by structures or deposited in channels, and repair to structures and/or erosion protection, if and as needed. Permanent access roads to the structures is required to facilitate maintenance. A financial plan will need to be developed for funding maintenance and post-event restoration. An operations and maintenance manual will need to be developed at construction completion.

6. PROPOSED MITIGATION DESIGN

6.1. Design Elements and Functionality

The following sections describe the design and functionality of key components of the proposed mitigation design (Drawing 01).

6.1.1. Deflection Structure and Inlet Ramp

Upstream of the FHSR pond a debris flood deflection structure in the form of a concrete wall with slot outlet will be constructed to direct debris floods and associated sediment into the basin. This will allow sediment to deposit in the basin area rather than filling the FHSR pond[3]. Storage provided by the proposed basin exceeds the estimated total volume of debris flood sediment, and the basin therefore protects infrastructure downstream of the basin from sedimentation.

The concrete diversion structure would be approximately 2 m high, 15 m long with an opening that allows clearwater flows to pass through the structure and follow the current creek channel. The structure would be wide enough for single lane traffic during basin clean out (see Section 6.1.5 for more detail). An armoured channel, with an elevated inlet to only capture high flows, will direct debris floods onto the inlet ramp and into the debris basin. The deflection channel will require a grade control structure such as a concrete sill to prevent channel erosion. Debris flows would overtop this debris flood diversion structure and be stopped by the proposed barrier.

A ramp will be excavated to direct flows into the basin and provide more storage capacity than the natural topography. The ramp will be sloped at a 4H:1V downslope grade for approximately 50 m with an average width of 45 m. This ramp will require erosion protection such as grouted stone pitching for grade control. The grade control prevents retrogressive erosion that otherwise would eventually reach the creek, affecting water license intake and destabilize landslides further upstream.

[3] According to NHC (2019) the reservoir holds approximately 1,600 m^3. The concrete dam that defines the reservoir (Dam File No. D330122-00) is 22 long, 4.6 m tall.

Figure 6-1 Example of basin inlet ramp lined with grouted stone pitching (Photo courtesy of J. Hübl BOKU).

6.1.2. Barrier and Debris Basin

A debris basin will be excavated into native soil. The excavated dimensions are approximately 85 m wide by 65 m long, with a total excavated volume of 19,000 m^3.

The excavated material will be used as earth fill[4] to form a barrier on the downstream side of the debris basin. The barrier is 13 m tall at the creek thalweg and provides a total debris storage volume[5] of approximately 64,000 m^3. The upstream surface of the earth fill berm will be protected against erosion with grouted stone pitching.

The outlet structure will be embedded in the berm and designed as a concrete slot barrier with a steel rack (see example in Figure 6-2A and Figure 6-2C). The rack configuration will control the filtration of debris and allow water to pass. Should the basin be filled with debris to the top of the

[4] The barrier earth fill volume is 26,000 m^3. Basin cut and barrier fill balance will be optimized during detailed design.

[5] Storage volume accounts for debris depositional slope of 5%. The depositional slope is based on BGC's field observations during the 2020 field mapping at Cold Spring Creek. This corresponds to approximately 2/3 of the original bed slope angle. Note, 1/2 to 2/3 the bed slope angle is a rule of thumb that is often applied for debris basin design.

outlet structure, the concrete weir above the rack acts as spillway for a controlled discharge into the stilling basin downstream of the berm (see example in Figure 6-2B). The weir will have buried wingwalls embedded in the earthen berms to avoid outflanking erosion. The berm crest will be tapered to slope towards the weir.

The stilling basin will have concrete lateral walls and a concrete bottom with a counter sill at the downstream end.

Designing the outlet structure will require further study as part of the detailed design, to develop a configuration that suits the characteristics of debris flows at Cold Spring Creek. This also includes the interaction of large woody debris with the barrier. Open check barrier behaviour during floods is dramatically influenced by the presence or absence of driftwood (Piton and Recking 2015). Recent experience in Switzerland has resulted in novel designs whereby the large woody debris is filtered out upstream of the check barrier itself (Figure 6-2D).

A) Looking downstream at concrete slot barrier with inclined steel rack embedded within earth fill berm (Fischbach, Thalgau, Salzburg, Austria; photo from Hübl et al., 2005).

B) Looking obliquely downstream at stilling basin with concrete wing walls, concrete counter-sill and armoured bottom covered by sediment (Kleine Melchaa, Giswil, Switzerland; photo Sept. 2015 by Christian Imfeld, giswil.ch).

C) Looking downstream at concrete slot barrier with inclined steel rack embedded within earth fill berm at Mckay Creek in North Vancouver, BC (photo from Moase, 2017).

D) Filter for large woody debris (rust colored steel piles and horizontal wire ropes) upstream of an open check barrier to avoid blockage of the check barrier slot (covered with grey steel structure). Kleine Melchaa, Giswil, Switzerland (photo 2019 by M. Busslinger).

Figure 6-2 Barrier and channel outlet examples.

6.1.3. Outlet Channel

Downstream of the berm concrete slot outlet, the creek channel will be armoured with grouted stone pitching for a length of 50 m to prevent erosion from retrogressing and undermining the outlet structure or entraining natural creek bed material. Further analysis is required during final design to refine the downstream channel size to complement the chosen outlet structure geometry.

6.1.4. Cold Spring Creek Channel Upgrade downstream of Debris Basin

An assessment by NHC (2019) included the Cold Spring Creek channel downstream of the proposed barrier. The channel descriptions suggest limited conveyance capacity. Although they did not explicitly evaluate existing culverts, NHC noted that the culverts may be undersized.

During the design debris flow, the water peak discharge from the debris basin would likely overwhelm the limited conveyance capacity of Cold Spring Creek. Further discussions with MOTI, who administer the roads, are required to resolve this issue.

6.1.5. Access Road, Watermains, FHSR Pond

The proposed debris basin and berm will encroach on the existing watermains and current access road (Drawing 01). The watermains will be rerouted, potentially along the new access road.

A new access road would be constructed above the left (south) abutment of the berm to run between Fairmont Resort Road to the west and the existing access road upstream of the berm. This access road allows machinery such as excavators, bull dozers and trucks to enter the debris basin for clean out after a large event and routine maintenance.

6.2. Performance Expectations

The proposed barrier is designed to retain debris from the estimated 100-300 year debris flow, while allowing passage of clear water flows. Maximum particle size passing the barrier will be controlled by the outlet structure. The outlet structure will be designed to capture boulders and large woody debris and will limit the discharge that exits the basin. The proposed design will have a slot opening in the outlet structure, which allows water to pass the structure in a controlled manner when the basin is empty or partially filled. The slot opening avoids ponding water in the basin. Ponded water could occur in the basin if the slot opening is blocked, until the blockage is removed. If the slot opening is completely blocked, ponded water will spill over the outlet structure weir, and be directed by the stilling basin into the upgraded channel.

The outlet structure needs to balance the competing objectives of capturing sediment and wood during damaging debris flows and debris floods, while allowing passage of debris that can be safely conveyed downstream to limit downstream environmental impacts and basin maintenance effort and cost. The outlet structure, particularly the steel rack, may require some adjustments to calibrate sediment flux to conditions that are encountered following construction. Similarly, the adjustments may be required to optimize the filtration of large woody debris. Flexibility for adjustment will be incorporated in the detailed design of the steel rack, and limits of adjustment will be described in the operations and maintenance manual.

Events that exceed the basin capacity (e.g., events larger than the design event, events that occur before the basin is cleaned out) will spill over the weir located on top of the outlet structure. These flows are likely to exceed the downstream channel capacity and may impact buildings and infrastructure. An extreme event that exceeds the weir capacity (i.e., much larger and rarer than the design event) may overtop the berm crest outside the weir, possibly leading to erosion through the earth fill barrier. In this worst-case scenario, earth fill from the barrier could be entrained in the debris flow that continues downstream. As such, the proposed mitigation reduces, but does not eliminate debris flow risk.

Periodic inspection and maintenance will be required as outlined in Section 5.11. In order to function as intended the debris basin needs to be cleaned out to provide the design storage capacity after significant events. Given that most debris flood and debris flow will deposit in the basin, it requires off-site transport to a permanent debris storage facility. Should there be a market for aggregate, some of the deposited debris could be sold, provided it meets quality requirements.

6.3. Schedule and Permitting Considerations

The schedule and permitting considerations discussed below were prepared by McElhanney with input from RDEK, Lotic and BGC.

6.3.1. Environmental and Permitting Considerations

A number of environmental and regulatory permits will be required for the construction of the proposed debris basin and berm. Key permitting and approvals components are listed in Table 6-1, along with expected approval timelines.

Table 6-1. Required permitting and approval components and approximate timelines.

Regulatory Instrument	Likelihood	Timing (Approximate)
Fisheries Act Request for Review or Authorization	Unlikely	30-90 days
Water Sustainability Act Section 11 Approval	Certain	Typically 120 days
Wildlife Act – Fish/Wildlife Salvage Permit	Possible	40-60 days
BC *Dike Maintenance Act* Approval	Certain	60-90 days

A fish presence/absence study has already been completed at the proposed project site, and no fish were identified. Fish were only discovered in Cold Spring Creek downstream of Highway 93/95. Therefore, regulatory submission under the *Fisheries Act* is not expected to be required. Approval is required under BC's *Water Sustainability Act* for Works In and About a Stream. This approval is necessary before any work in the riparian zone of Cold Spring Creek, including initial tree clearing. BGC notes that the WSA approval is likely the schedule-critical approval for this project.

From communication with RDEK[6], the project team understands that environmental assessments are required where dam height exceeds 15 m and water storage exceeds 10,000,000 m^3. The proposed barrier height for this project is 13 m, with a proposed storage capacity of 68,000 m^3. Therefore, an environmental assessment is not expected to be required for this project.

The proposed design will have a slot opening in the outlet structure. The barrier is not watertight or storing water and therefore dam safety regulation or water licence for storage do not apply.

RDEK has already arranged discussions with the Deputy Inspector of Dikes and this proposed debris basin and berm will be registered as a flood protection structure under the BC *Dike Maintenance Act*. At this time, the project team understands that dike design specifications will not apply to the proposed project, as they are not relevant, based on discussions with the Deputy Inspector of Dikes.

6.3.2. Schedule

The project team understands the following milestones apply for this project:

- March 31, 2021 Grant funding announcement and project kick-off
- May 1, 2021 Initial regulatory permit applications (primarily WSA)
- June 1, 2021 Tender posting for Contract 1 (clearing, access road construction, site preparation)
- September 1, 2021 Construction start date for Contract 1
- November 30, 2021 Construction completion for Contract 1
- January 1, 2022 Tender posting for Contract 2 (barrier construction and associated works)
- July 1, 2022 Construction start date for Contract 2
- December 31, 2022 Construction completion for Contract 2

RDEK plans to tender the project in two separate tenders. The aim of this split is to optimize schedule, especially around seasonal work windows, and to separate out typical civil construction from specialty debris basin work.

The first tender, Contract 1, would be tendered early in the overall design process, and would incorporate key civil components such as tree clearing and grubbing, access road construction, and site preparation. RDEK may also elect to incorporate basin excavation, likely tendering it as 'Optional Work'. This contract will be completed in fall 2021 – well after freshet, after bird nesting windows, but before significant snow accumulation or freeze up.

The second tender, Contract 2, would be tendered after the full hydrotechnical, geotechnical and structural design of the debris basin and berm is completed. This contract would be completed in summer and fall 2022, after spring freshet on Cold Spring Creek.

[6] Email from K. Zandbergen (Jan. 7, 2020) forwarding input from BC Dam Safety Officer (Kate Forbes).

The project team understands that the preferred tender scheduling is in the winter or early spring of each year. Local Contractors tend to be more aggressive with prices in the spring, and there is anecdotally more tender competition earlier in the year. Both contract tender dates were therefore planned for early in the calendar year to hopefully result in the lowest possible tender prices.

6.4. Cost Opinion

6.4.1. Methods and Assumptions

For this Class "D" cost opinion, BGC developed costing line items following the structure of the ARDM cost estimate spreadsheet template. BGC estimated quantities (e.g. volume of earthworks) for each design element. McElhanney provided unit rates based on their experience with local construction projects. Where required, costs were scaled from other projects based on McElhanney's and BGC's experience, as well as case studies for similar mitigation structures.

Key costing assumptions are listed for each main item below:

1. Project planning includes lump sum costs for environmental studies, environmental permits and monitoring, and stakeholder consultation.
2. Design / engineering includes lump sum costs for geotechnical site investigation, detailed design and preparation of IFT documents, and construction field reviews.
3. Construction / materials are based on quantities estimated for the proposed mitigation design (Drawing 01) and assumed unit rates.
    a. Costs include a lump sum cost for mobilization and demobilization, and a lump sum cost for environmental protection, water management, and sediment control and monitoring for construction in the riparian zone.
    b. It is assumed that existing watermains will be decommissioned and re-routed along the proposed access road. A higher unit rate was applied for construction of the watermain from the FHSR reservoir because the pipe will be routed underneath the proposed earth fill berm and subject to higher confining pressures.
    c. The deflection structure assumes a lump sum for a concrete structure that could be trafficked for basin clean-outs. The basin inlet ramp (i.e. excavated inclined slope towards the basin bottom) will be armoured with grouted stone pitching, with a unit rate based on the cost of class 250 kg riprap with concrete assuming a 30% void ratio.
    d. Material excavated from the basin will be placed as earth fill for the barrier (cut-fill volumes will be optimized in detailed design).
    e. Assumptions were made for the dimensions of the concrete slot barrier, spillway, and steel rack for the purposes of costing, and material volumes were compared to outlet structures of similar size. The base of concrete slot barrier is assumed to be grouted stone pitching.
    f. The outlet channel costs include excavation and grouted stone pitching.
4. Other eligible costs include a lump sum allowance for initial monitoring of the outlet structure to calibrate the steel rack configuration to conditions.
5. The cost opinion is considered a Class "D" estimate, and therefore a 50% contingency is assumed per cost estimate classes in ARDM costing template.

6.4.2. Results

The estimated Class "D" cost opinion is for $9.72 Million (in 2021 Canadian Dollars), which includes a 50% contingency. Table 6-3 summarizes costs for the key components. Appendix A provides cost estimating details.

Table 6-2. Summary of cost opinion.

Item	Description	Cost
1.0	Project Planning	$75,000
2.0	Design / Engineering	$820,000
3.0	Construction / Materials	$5,567,000
4.0	Other Eligible Costs	$20,000
5.0	Contingency	$3,241,000
	Total	**$9,723,000**

Notes:
1. Refer to Appendix A for cost estimating details.
2. Costs do not include GST.
3. Costs are in 2021 Canadian Dollars.
4. Costs are rounded to the nearest $1,000.
5. Costs are Class "D". A contingency has been included in the cost opinion to account for additional items of work or changes to the quantities incorporated into the project during the preparation of detailed design.
6. Other costs which are not captured in the cost opinions include (but are not limited to): ineligible costs for ARDM funding application (to be developed separately by the RDEK); upgrades to existing road or drainage infrastructure downstream of the barrier; operational and maintenance costs; and other costs normally incurred by the owner. Actual construction costs are contingent upon market conditions at the time of tender.

6.4.3. Discussion

The highest uncertainty in this cost opinion is associated with the cost of the outlet structure because its configuration requires further study and refinement as part of the detailed design. The cost is estimated at $1.4 Million, based on three different methods: 1) scaling cost from similar structures in BC by passage area, 2) scaling cost from similar structures in BC by concrete volume and steel weight, and 3) estimating costs using typical unit rates for reinforced concrete, steel, grouted stone pitching for assumed, preliminary dimensions of the outlet structure.

The cost estimate is sensitive to the unit rate of grouted stone pitching and concrete. Suitability of local earth fill supply and foundation design will depend on the findings from the geotechnical site investigation. Costs associated with decommissioning existing infrastructure might depend on as-built surveys.

6.4.4. Limitations of Cost Opinion

These cost opinions were developed for funding considerations. As noted on Table 6-3, cost opinions provided in this report are preliminary (Class "D" ±50% per ARDM cost estimate classes), and only consider project planning, design and engineering, construction and materials, other eligible costs, and contingency, based on the available site information and the probable conditions affecting the project. A rigorous quantitative risk and cost analysis was beyond the scope of this assessment. Variations larger than the 50% contingency are possible if the design concepts or risk reduction targets are significantly changed. Explicit items which are excluded from the cost opinions are listed in the footnotes of Table 6-3.

7. CONCLUSIONS AND RECOMMENDATIONS

Risks posed by debris flows at Cold Spring Creek are unacceptably high. The proposed design significantly reduces these risks at infrastructure and buildings on Cold Spring Creek fan.

This report provides a preliminary design of a debris basin to retain up to 64,000 m^3 of debris for mitigation of debris flows occurring on Cold Spring Creek. This corresponds to a return period of a 100 to 300-year return period debris flow. The proposed design will substantially reduce (but not eliminate) life loss and economic risks posed by debris flows to the existing development. This design concept was chosen because it is estimated to be the most cost-effective manner of reducing debris flow risk at all buildings and infrastructure on Cold Spring Creek Fan.

The estimated Class "D" cost opinion is for $9.72 Million (in 2021 Canadian Dollars), which includes a 50% contingency.

BGC recommends the following next steps:

1. The RDEK should secure funding to execute the proposed project.
2. Approval for permits discussed in Section 6.3 should be obtained. Given the length of the approval processes and the September 30, 2021 construction start date stipulated by the ARDM guideline, BGC recommends that permit applications be issued as soon as possible and before the funding decision is made in the Spring of 2021.
3. The RDEK should continue stakeholder engagement, public consultation and formalize land use agreements for this project, including realignment of water lines and reservoir protection.

7.1. Further Work

The following list outlines further work required during subsequent design phases:

- As-built drawings of existing infrastructure should be obtained and where necessary surveyed to facilitate detailed design.
- A geotechnical site investigation should be carried out to:
  - characterize the barrier foundation conditions for soil and rock.
  - characterize hydrogeological conditions (i.e., groundwater levels).
  - proof out quantities and quality of borrow material excavated from the debris basin to build an earth fill berm.
- Geotechnical, hydrotechnical and structural analyses (including seismic loading) will need to be carried out to inform detailed design. The design should comply with the regulations and guidelines listed in Section 5.1, where applicable.
- During the design debris flow, the water peak discharge from the debris basin would likely overwhelm the limited conveyance capacity of Cold Spring Creek. Hydraulic sizing during detailed design of the proposed debris basin outlet should limit peak water discharge to values that can be conveyed in an upgraded downstream creek channel.
- Downstream of the proposed debris basin, upgrades to the creek channel and culverts will be required to pass the design flows. This should be resolved with MOTI who administers the roads.
- Optimization of design layout to refine construction and design efficiency.

- Detailed design of berm outlet structure to consider Cold Spring Creek debris flow characteristics and final quantitative risk analysis findings.
- Detailed design of site access road alignment with input from stakeholders.
- Relocation planning of existing watermains.
- Evaluate benefits of relocating existing FHSR pond downstream of proposed barrier.
- Earthworks and material handling during construction should limit the amount of debris that could be entrained (e.g., from stockpiles) by a debris flood or debris flow.
- A detailed cost estimate by a qualified cost estimator will need to be developed for the detailed design.
- A financial plan for funding operations and maintenance costs is being developed by the RDEK.
- An operations and maintenance manual needs to be developed, including a plan for disposal of sediment and debris that is removed from the basin.

8. CLOSURE

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC ENGINEERING INC.
per:

Jan 11, 2021

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REFERENCES

BC Ministry of Environment, Lands and Parks (2000, March). *Riprap Design and Construction Guide.* Last accessed January 2021: http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/riprap_guide.pdf

BC Ministry of Forests, Lands and Natural Resource Operations Flood Safety Section. (2014, June). *Seismic Design Guidelines for Dikes, 2nd Edition*. Last accessed January 2021: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/seismic_guidelines_dikes-2014-2nd_edition.pdf

BC Ministry of Water, Land & Air Protection (2003, July). *Dike design and construction guide: Best Management Practices for British Columbia*. ISBN 0-7726-4996-0. Last accessed January 2021: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/dike_des_cons_guide_july-2011.pdf

BGC Engineering Inc. (BGC). (2020, September 25). *Cold Spring Creek Hazard Assessment* [Letter Report]. Prepared for Regional District of East Kootenay.

BGC Engineering Inc. (BGC). (2020, December 16). *Mitigation Options Analysis* [Letter]. Prepared for Regional District of East Kootenay.

Church, M., & Jakob, M. (2020). What is a debris flood? *Water Resources Research*, Advance online publication. https://doi.org/10.1029/2020WR027144.

Clarke Geoscience Ltd. and Tetra Tech EBA. (2015, March 1). *Cold Spring Creek Debris Flow Hazard and Risk Assessment* [Report]. Prepared for Regional District of Eastern Kootenay.

FLO-2D Software. (2020). FLO-2D Pro (Version 18.12.20) [Computer Software].

Hungr, O., Leroueil, S., & Picarelli, L. (2014). The Varnes classification of landslide types, an update. *Landslides*, 11(2), 167-194. https://doi.org/10.1007/s10346-013-0436-y

Hübl, J., Holub, M., Ganahl, E., Moser, M., & Wehrmann, H. (2005): CHECKDAM - Evaluierung offener Wildbachsperren unter Lastannahme, IAN Report 69. Bundesmin. f. Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Abt. IV/4, IV/5, 296 S.

Moase, E. (2017). *Guidance for debris-flow and debris-flood mitigation design in Canada* (Master's thesis). Simon Fraser University, Burnaby, BC.

Northwest Hydraulic Consultants Ltd. (NHC). (2019, October 20). *Cold Spring Creek 2019 Debris Flood Assessment and Mitigation Concept Design* [Letter Report]. Prepared for Regional District of Eastern Kootenay.

Northwest Hydraulic Consultants Ltd. (NHC). (2020, June 24). *Fairmont Creek Debris Basins – May 31, 2020 Flood Assessment* [Report]. Prepared for Regional District of East Kootenay.

Piton, G., & Recking, A. (2015). Design of sediment traps with open check dams. II: woody debris Journal of Hydraulic Engineering 142 (2), 04015046.

Regional District of East Kootenay (RDEK). (2017). *Fairmont Hot Springs & Columbia Lake Area Official Community Plan* (Bylaw No. 2779, 2017). Cranbrook, BC: Author.

Town of Canmore. (2016). *The Town of Canmore Municipal Development Plan* (Bylaw 2016-03). Canmore, AB: Author.

APPENDIX A
COST OPINION

Cost Opinion (Class D)
Cold Spring Creek Debris Basin

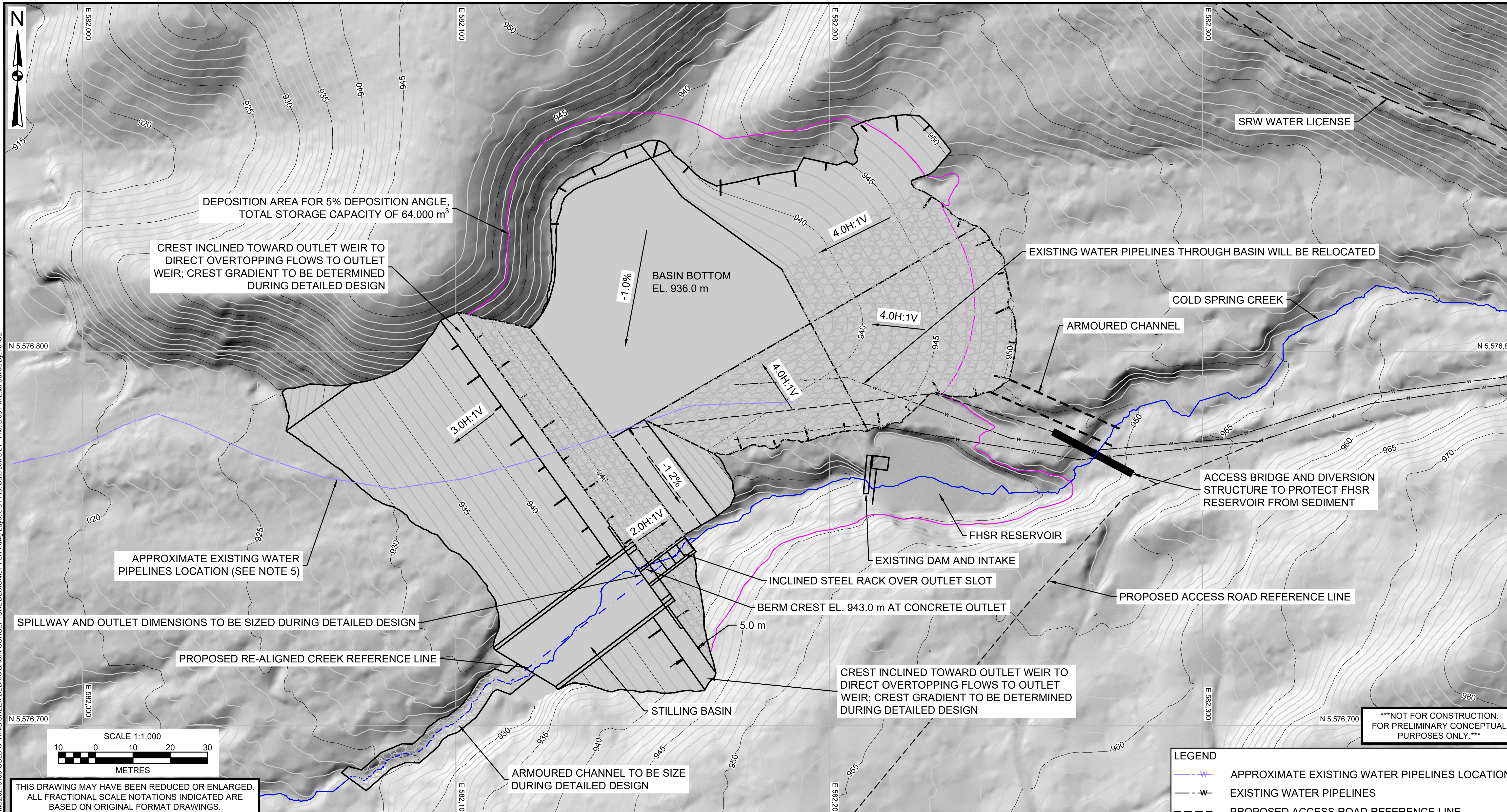
Item	Summary of Preliminary Estimate	Total
1.0	Project Planning	$ 75,000
2.0	Design / Engineering	$ 820,000
3.0	Construction / Materials	$ 5,567,000
4.0	Other Eligible Costs	$ 20,000
5.0	Contingency	$ 3,241,000
	Eligible Costs	**$ 9,723,000**
6.0	Ineligible Costs	$ -
	Total Gross Project (Eligible + Ineligible)	**$ 9,723,000**

Item	Description	Unit	Est. Quantity	Est. Unit Price	Est. Total
1.0	**Project Planning**	**Unit**	**Est. Quantity**	**Est. Unit Price**	**Est. Total**
1.1	Environmental Studies	lump sum	1	$ 50,000	$ 50,000
1.2	Environmental Permits and Monitoring	lump sum	1	$ 15,000	$ 15,000
1.3	Stakeholder Consultation	lump sum	1	$ 10,000	$ 10,000
				Sub-total Item 1.0	**$ 75,000**
2.0	**Design / Engineering**	**Unit**	**Est. Quantity**	**Est. Unit Price**	**Est. Total**
2.1	Geotechnical Site Investigation	lump sum	1	$ 70,000	$ 70,000
2.2	Detailed Design, Preparation of IFT Documents	lump sum	1	$ 500,000	$ 500,000
2.3	Construction Field Reviews	lump sum	1	$ 250,000	$ 250,000
				Sub-total Item 2.0	**$ 820,000**
3.0	**Construction / Materials**	**Unit**	**Est. Quantity**	**Est. Unit Price**	**Est. Total**
3.1	**Preliminaries**				
i	Mobilization / Demobilization	lump sum	1	$ 250,000	$ 250,000
ii	Enviromental Protection, Water Management, Sediment Control	lump sum	1	$ 200,000	$ 200,000
				Sub-total Item 3.1	$ 450,000
3.2	**Access Road, Watermains, FHSR Pond**				
i	Access Road Clearing, Grubbing, Cut, Fill	m	370	$ 275	$ 102,000
ii	FHSR Reservoir Buried Watermain	m	120	$ 2,000	$ 240,000
iii	Watermain Decomissioning	lump sum	1	$ 14,000	$ 14,000
iv	Watermain Construction	m	400	$ 700	$ 280,000
				Sub-total Item 3.2	$ 636,000
3.3	**Deflection Structure and Inlet Ramp**				
i	Deflection Structure with Access Bridge	lump sum	1	$ 300,000	$ 300,000
ii	Inlet Ramp Armouring, Grouted Stone Pitching	m3	3,700	$ 340	$ 1,258,000
				Sub-total Item 3.3	$ 1,558,000
3.4	**Debris Basin**				
i	Clearing, Grubbing, Disposal	m2	8,800	$ 7	$ 62,000
ii	Excavation	m3	19,300	$ 10	$ 193,000
				Sub-total Item 3.4	$ 255,000
3.5	**Debris Barrier**				
i	Clearing, Grubbing, Disposal	m2	5,500	$ 7	$ 39,000
ii	Earth Fill Placement from Basin	m3	19,300	$ 15	$ 290,000
iii	Additional Earth Fill Supply	m3	7,000	$ 45	$ 315,000
iv	Concrete Slot Barrier, Spillway, Steel Rack	lump sum	1	$ 1,400,000	$ 1,400,000
v	Face Armouring, Grouted Stone Pitching	m3	1,200	$ 340	$ 408,000
				Sub-total Item 3.5	$ 2,452,000
3.6	**Outlet Channel**				
i	Excavation	m3	600	$ 20	$ 12,000
ii	Channel Armouring, Grouted Stone Pitching	m3	600	$ 340	$ 204,000
				Sub-total Item 3.6	$ 216,000
				Sub-total Item 3.0	**$ 5,567,000**
4.0	**Other Eligible Costs**	**Unit**	**Est. Quantity**	**Est. Unit Price**	**Est. Total**
1	Monitoring / Steel Rack Configuration Optimization	lump sum	1	$ 20,000.00	$ 20,000
				Sub-total Item 4.0	**$ 20,000**
5.0	**Contingency**	**Unit**	**Est. Quantity**	**Est. Unit Price**	**Est. Total**
1	Class D	%	50%	$ 6,482,000	$ 3,241,000
				Sub-total Item 5.0	**$ 3,241,000**
6.0	**Ineligible Costs**	**Unit**	**Est. Quantity**	**Est. Unit Price**	**Est. Total**
1	Land Acquisition Cost	lump sum	1		$ -
2	Leasing Land, Building and Other Facilities	lump sum	1		$ -
3	Financing Charges	lump sum	1		$ -
4	Legal Fees	lump sum	1		$ -
5	In-kind Contribution	lump sum	1		$ -
6	Tax Rebate	lump sum	1		$ -
7	Other	lump sum	1		$ -
				Sub-total Item 6.0	**$ -**

Notes:

1) Refer to report for assumptions.
2) Costs do not include GST.
3) Costs are in 2021 Canadian Dollars.
4) Costs are rounded to nearest $1,000.
5) Costs are Class "D". A contingency has been included in the cost opinion to account for additional items of work or changes to the quantities incorporated into the project during the preparation of detailed design.
6) Other costs which are not captured in the cost opinions include (but are not limited to): ineligible costs for ARDM funding application (to be developed separatly by the RDEK); upgrades to existing road or drainage infrastructure downstream of the barrier; operational and maintenance costs; and other costs normally incurred by the owner.
7) Actual construction costs are contingent upon market conditions at the time of tender.

DRAWINGS



THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "COLD SPRING CREEK - DEBRIS FLOW BASIN MITIGATION DESIGN", AND DATED JANUARY 2021.
3. LIDAR DATA PROVIDED BY REGIONAL DISTRICT OF EAST KOOTENAY, PREPARED ON SEPTEMBER 12, 2018. CONTOUR INTERVAL IS 1.0 m.
4. COORDINATE SYSTEM IS NAD83 UTM ZONE 11N. VERTICAL DATUM IS CGVD28.
5. WATER PIPELINE DIGITIZED LOCATION NOT ENTIRELY AVAILABLE. WATER PIPELINE LOCATION APPROXIMATELY FOLLOWS EXISTING ACCESS ROAD ALIGNMENT.
6. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

REVISION INFORMATION

REV. NO.	YEAR	MM	DD	DRAWN	DESIGN	REVIEW	APPROVED	REVISION / ISSUED DESCRIPTIONS	REV. NO.	YEAR	MM	DD	DRAWN	DESIGN	REVIEW	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	-	-	-	RH	BCP	MB	AS	PERLIMINARY DESIGN ISSUED FOR FUNDING APPLICATION									

PERMIT AND STAMP:

CLIENT: Regional District of East Kootenay

BGC

PROJECT: COLD SPRING CREEK - DEBRIS FLOW BASIN MITIGATION DESIGN

TITLE: GENERAL ARRANGEMENT

SCALE: 1:1,000 | DWG No.: 01 | REV.: A

C:\ Vault\Projects\1572-EGLEM-CAD\Production\Report-Memo\20210105-COLD SPRING CREEK DEBRIS BASIN CONCEPTUAL DESIGN\01-PLAN.dwg Layout: 01 Plot Date Jan 8 21 Time: 5:08 PM Last Saved By: RHSU